HAWAIIAN FRUIT FLIES LABORATORY

AGRICULTURAL RESEARCH SERVICE
Western Region — Southern California-Hawaii Area
of the
U.S. DEPARTMENT OF AGRICULTURE

DEDICATION

OF

NEW RESEARCH FACILITIES

Honolulu, Hawaii

October 10, 1973

History of Fruit Fly Research in Hawaii

Hawaii is the only place where three of the world's most serious agricultural pests, the oriental fruit fly *(Dacus dorsalis* Hendel), the melon fly *(Dacus cucurbitae* Coquillett), and the Mediterranean fruit fly *(Ceratitis capitata* [Wiedemann]), occur together. These insects are highly destructive pests of fruits and vegetables and of many nuts and flowers. Collectively, they attack more than 200 different hosts in Hawaii. In addition, a constant hazard exists that one or more of these destructive fruit flies may be introduced into the continental United States, despite constant and rigid quarantines, because of increased tourist travel and world trade.

The melon fly is thought to have been introduced into Hawaii about 1895, probably from Australia, and the oriental fruit fly about 1944, probably from Saipan. The oriental fruit fly and the Mediterranean fruit fly are major pests of citrus fruits, mangoes, guavas, peaches, apricots, coffee, English walnuts, breadfruit, bananas, papayas, cantaloupes, tomatoes, and many other hosts, while the melon fly is the vegetable grower's worst pest, attacking tomatoes and many cucurbits.

In 1912, soon after the introduction of the Mediterranean fruit fly, the old Bureau of Entomology of the United States Department of Agriculture established a laboratory in Hawaii which, until 1931, was located on the grounds of the Territorial Board of Agriculture near downtown Honolulu. The laboratory was called "Mediterranean Fruit Fly Investigations"; however, the research included studies of the melon fly also. The major activities were biology and life history investigations, and the introduction of parasites to control these two fruit fly species. For this purpose, the Bureau of Entomology engaged the services of the noted Italian entomologist, F. Silvestri, who traveled to many parts of Africa and sent back fruit fly parasites to Hawaii.

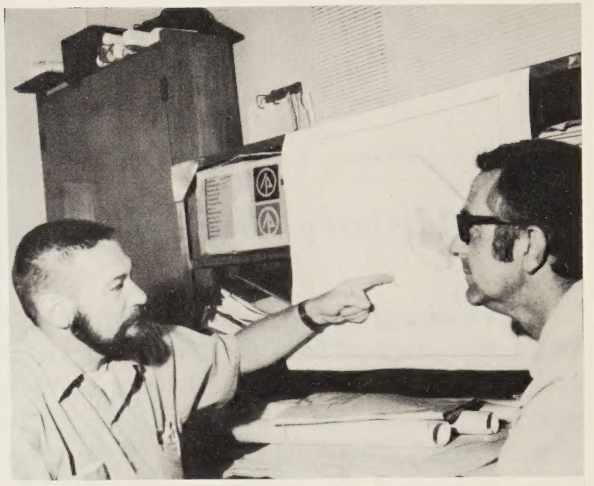
Research Leader of Hawaiian Fruit Flies Laboratory, Ernest J. Harris (left), and Chairman of Department of Entomology, University of Hawaii, Wallace C. Mitchell, discuss mutual problems and plan cooperative efforts.

In 1929 there was a major outbreak of the Mediterranean fruit fly in Florida, which was suppressed by 1930 at a great cost in time and effort. In late 1930, the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture sent additional entomologists and chemists to Hawaii to augment the staff and to further research on fruit fly control along additional lines. Entomology and Plant Quarantine officials made arrangements with the University of Hawaii for the construction of a fruit fly research building on the campus. The new facility was completed and occupied in 1931. In addition to research with insecticides, investigations were concerned with establishing minimum requirements for fruit fly disinfestation of export commodities by refrigeration and by treatments with hot water.

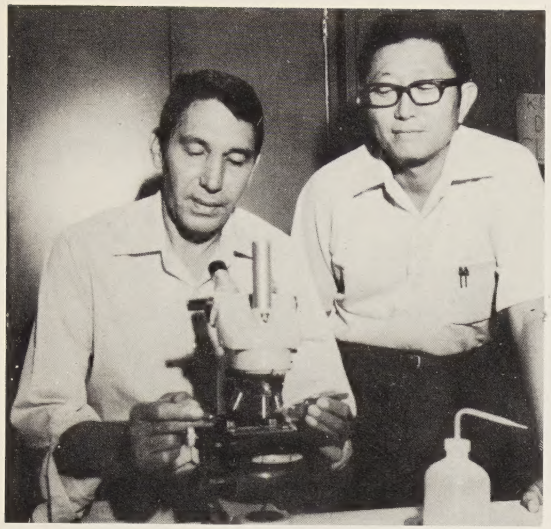
When the oriental fruit fly was introduced into Hawaii and began its rapid population explosion, the fruit fly program was greatly enlarged. From 1949 to 1951, the University of California, University of Hawaii, Hawaii State Department of Agriculture, Pineapple Research Institute, and the Hawaiian Sugar Planters' Association Experiment Station worked in a cooperative program with the Bureau of Entomology and Plant Quarantine to introduce parasites of fruit flies collected from Asia and Africa, and to develop other methods of control. Also, in 1949, fruit fly laboratories and field substations were established on the islands of Lanai, Maui, and Hawaii. The Lanai laboratory was closed at the end of 1951, and the Maui laboratory in 1964. A new Lanai station was opened in 1972 in conjunction with large-scale area control and eradication studies on that island.

The laboratory on the island of Hawaii has been functioning continuously to date since its inception, and new facilities were built in 1965 by the federal government on a University farm near Hilo. The large land areas available through private and state cooperators on the Big Island (Hawaii) provide for test plots measured in square miles which are necessary for realistic measurements on the highly mobile fruit flies.

After the reorganization of the Bureau of Entomology and Plant Quarantine, the Hawaiian Fruit Flies Laboratory was under the aegis of the Entomology Research Division of the Agricultural Research Service; and, since 1972, is a research laboratory under the jurisdiction of the Southern California-Hawaii Area of the Western Region, Agricultural Research Service.



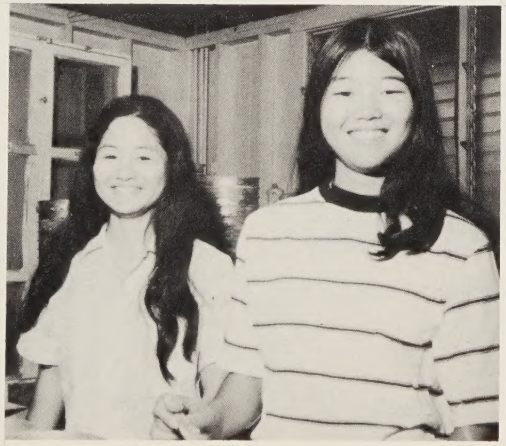
Entomologist Roy Cunningham presents proposed area control and eradication program on the island of Lanai to visiting assistant area director Peter H. van Schaik.



Gilbert Farias (left) and Entomologist Susumu Nakagawa making sperm counts in fruit fly competitive mating studies at Hilo.

In October, 1973, the main station in Honolulu was moved to our new facility, a four-building complex also on the campus of the University of Hawaii but located in upper Manoa Valley. The old building, occupied for 42 years, will be demolished by the University as part of its master plan for campus reconstruction. We enter this third phase of fruit fly research with confidence and enthusiasm, studying and developing new and better methods for fruit fly control coupled with maintenance of a wholesome environment.

Research fellows from many countries as Muhammed Anwar (left) and Nasrullah Chatha from Pakistan work at the laboratory for periods up to one year, sponsored by the International Atomic Energy Agency.



Dixeem Shimabukuro (left) and Lynn Shiige, students from the University of Hawaii, Hilo Campus, hired for the summer to assist in technical operations associated with area control and eradication studies of fruit flies.

Biology and Life History Studies.

These involve such studies as insect behavior, fruit fly movement, host preferences, economic damage, and effectiveness of parasites, and are basic to effective control and eradication programs and commodity treatments. Adult fruit flies can live several months, produce as many as 10 generations a year, can fly or be carried on winds for distances up to at least 45 miles, and can live in Hawaii at altitudes of as high as 6500 feet.

Mediterranean fruit flies have more than 200 hosts, principal among which are citrus, peach, pear, plum, apple, mango, guava, tropical almond, loquat, and coffee. Oriental fruit flies attack many fruits, flowers, and nuts, including pineapple, banana, coffee, guava, mango, papaya, citrus, cotton, peach, fig, cherry, apple, pear, plum, avocado, cucumber, and many others. Melon flies attack nearly all cucurbits, including watermelon, bitter melon, cantaloupe, squash, pumpkin, gourd, tomato, cucumber, cowpeas, string bean, wild momordica, plus many others. With all three species, damage is due to larvae feeding and tunneling in the fruit, stems, and blooms, and to "stings" which mar the fruit skin.

Melon flies.

Peaches on Maui infested with Mediterranean fruit flies.

Oriental Fruit flies. Note female top center ovipositing in artificial egging receptacle.

Eggs of fruit flies.

Larvae of fruit flies.

Pupae of fruit flies.

Commodity Treatments.

The first commodity treatment against fruit flies was the vapor heat treatment developed during the 1930's in which the produce was heated at 110°F for nearly 17 hours. However, the heat treatment could not be tolerated by many commodities, and in 1949, the need for new treatments led to further research on developing methods for treating infested commodities. Over 200 liquid chemicals for fumigation were evaluated, and vaporized ethylene dibromide was discovered to be an effective disinsecting agent. The use of ethylene dibromide opened the export market to the Hawaiian papaya industry. Now papayas can be shipped to other parts of the world as well as to the continental United States. Integrated treatments are being developed which involve a combination of fumigation, heating, and refrigeration. Smaller amounts of fumigants are needed in integrated treatments.

Research on gamma irradiation as a disinfestant was begun in 1954 using a radioactive Cobalt source of 1 curie. In 1957 a 415-curie gamma irradiator, the first of its kind in Hawaii, was obtained, and used to establish minimum doses required to destroy fruit flies in mangoes, papayas, bell peppers, tomatoes, and other fruit, and the mango weevil in mangoes. In 1967 a pilot gamma irradiator was built by the Atomic Energy Commission and State of Hawaii and is used jointly by all cooperating agencies for further research on the gamma irradiation of export commodities. Irradiation with microwaves is also being studied.

Newer methods of disinsectization of produce have been developed such as irradiation of packaged fruits and vegetables. Clifford Lee is loading mangoes into the irradiator.

Experimental fumigation of produce to develop dosages and tolerances for shipping products out of fruit fly-infested regions.

Passengers' baggage examined by quarantine personnel at Honolulu International Airport to prevent inadvertent spread of fruit flies to continental United States and other countries.

Theodore Berkebile, plant quarantine inspector, impounding a papaya at Honolulu International Airport that may spread fruit flies to the continental United States.

Shop at Honolulu International Airport showing legal purchase of papaya, after proper fumigation, for shipment to continental United States, Japan, and other countries. Treatment tolerances were developed by Hawaiian Fruit Flies Laboratory.

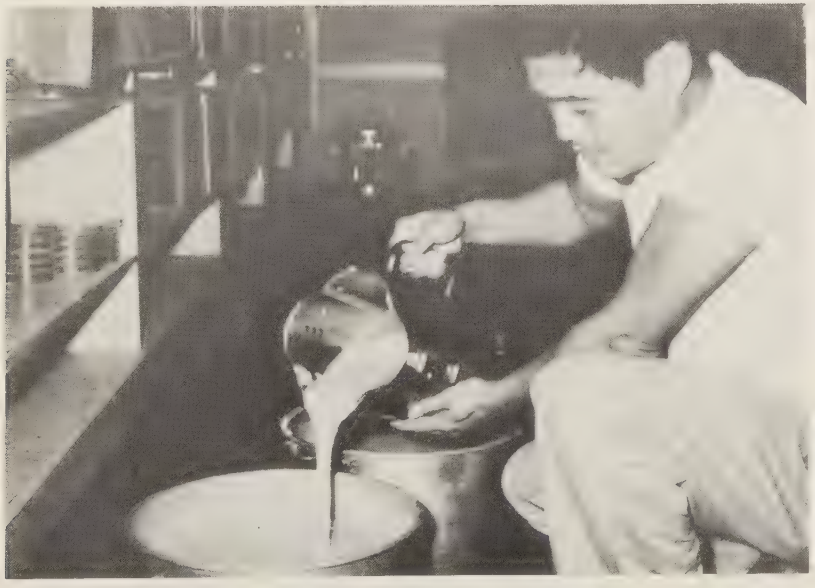
Sex Pheromones.

Males of the Mediterranean fruit fly, melon fly, and oriental fruit fly synthesize and secrete pheromones which attract the females of their respective species. The sex pheromone of the Mediterranean fruit fly has already been isolated, identified, and synthesized. If the synthetic pheromone, which can be prepared relatively inexpensively, proves to be as attractive in the field as in laboratory tests, it will provide a valuable tool for detection, survey and control operations. Research is also being conducted to isolate and identify the sex pheromones of the oriental fruit fly and melon fly.

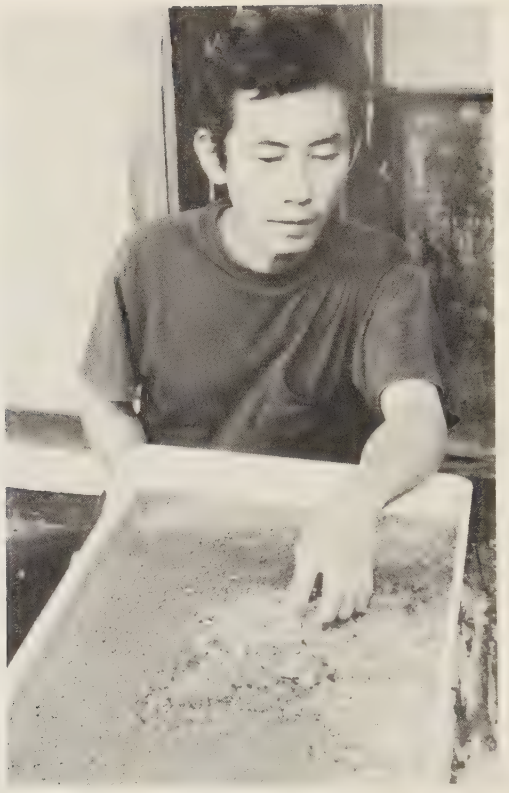
Female Mediterranean fruit flies attracted to test cup treated with pheromones. Control at left.

Mass Rearing of Fruit Flies.

The function of this activity is to provide eggs, larvae, pupae, and adults of all three species of fruit flies to the various research projects and cooperative agencies for their studies. Millions of fruit flies are reared each week for these purposes, such as evaluation of lures and insecticides, and commodity treatment studies. Also, many fruit flies are required for the special tests conducted in the Western Pacific and on the island of Lanai. With the development of the sterile fruit fly release control method, which demands millions of flies, a low-cost procedure for mass rearing fruit flies was developed. Current rearing methods are designed for maximum production up to 30 million pupae per week. Beyond this level, some areas in our handling methods may require automation which current production levels do not justify.



Richard Okamoto prepares larval medium for mass rearing of fruit flies.



Entomologist Norimitsu Tanaka checking larval development in artificial medium.

Chemical Control Studies.

These include evaluation of candidate insecticides in the laboratory and subsequent field testing of those with promise. "Promise" involves insecticides with not only high toxicity to fruit flies, but also with low mammalian toxicity plus other favorable attributes, assuring that they would not constitute a threat to the environment. An important chemical control activity is the continuous search for more effective lures for each of the three species of fruit flies that could be used in fruit fly control with or without an insecticide. At present we have three good lures that attract the males of each of the three species, and a special effort is being made to find powerful female lures. Chemical control studies also include research with insect juvenile hormones and chemosterilants.

Doris Miyashita evaluating several candidate fruit fly attractants at one time in a large walk-in olfactometer stocked with thousands of fruit flies.

Research Leader Ernest J. Harris studying the rate of volatilization of lures used to attract male fruit flies.

Finding a good lure makes Doris happy!

Isao Tomikawa testing residual effectiveness of insecticides applied under natural conditions by collecting foliage from the field after varying time intervals and exposing to adult fruit flies in the laboratory.

Robert Kinoshita sealing MATS airplane with screening cloth prior to release of free-flight experimental fruit flies within the plane.

Entomologist Irving Keiser demonstrating to naval officers a cage of experimental fruit flies to be released in a C-54 airplane during aircraft disinsectization studies.

Ivan Rainwater of Plant Quarantine spraying aircraft with experimental aerosol in cooperative study. Fruit flies contained in small screen cage in addition to free-flight released fruit flies.

Collecting released fruit flies after experimental aerosol treatment.

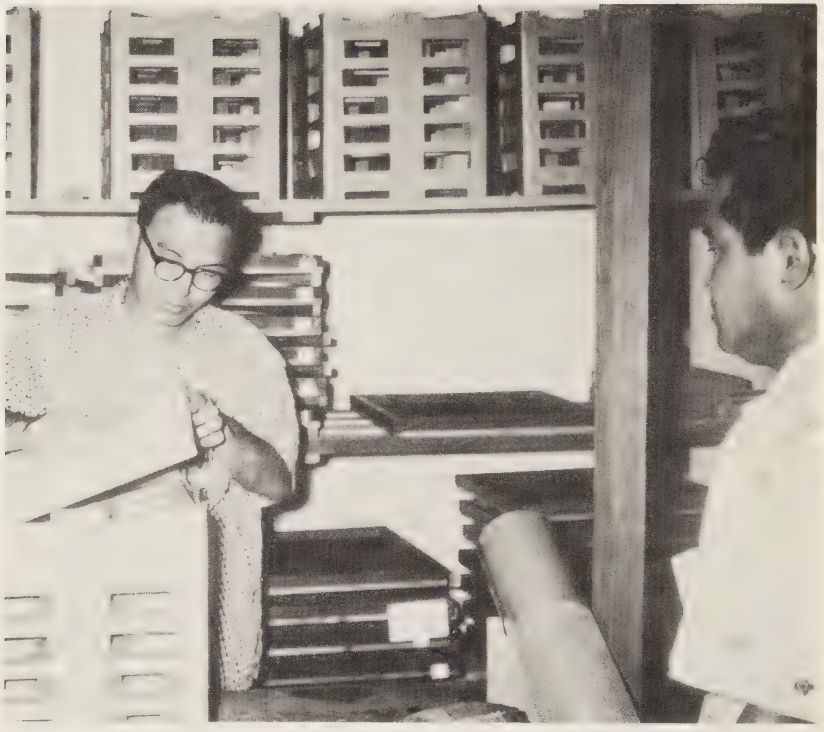
Area Control and Eradication Studies.

The information developed to control fruit flies is put to test in large study areas. Such large-scale studies were conducted on isolated islands in the Marianas, and involved the releases of large numbers of laboratory-reared fruit flies sterilized by irradiation. This development was first conceived by USDA entomologists and tested successfully on the screw-worm *(Cochliomyia hominivorax* [Coquerel]). The sterile fruit flies, when released in numbers many times greater than the population of wild fruit flies, mate with the wild females and thus prevent egg hatch. By continuing the release of sterilized fruit flies through several generations, the wild population diminishes and dies out. The melon fly was eradicated from Rota, a 33-square-mile island in the Marianas, in this manner, and involved the shipment of over a billion sterile melon flies which had been irradiated as pupae in the first Cobalt-60 irradiator in Hawaii. Later, the oriental fruit fly was eradicated from Guam (210 square mile) by the same method.

Studies are in progress to learn how radiation dosage, treatment conditions, and life stages of fruit fly development can be manipulated to obtain the most vigorous fruit flies for sterile release programs. Irradiation of the three species in the adult stage rather than in the pupal stage, and irradiation of pupae in modified atmospheres instead of in air are being studied. Other studies involve genetic quality—the maintenance of a fly strain that is competitive when released in the field, because of good genetic backround.

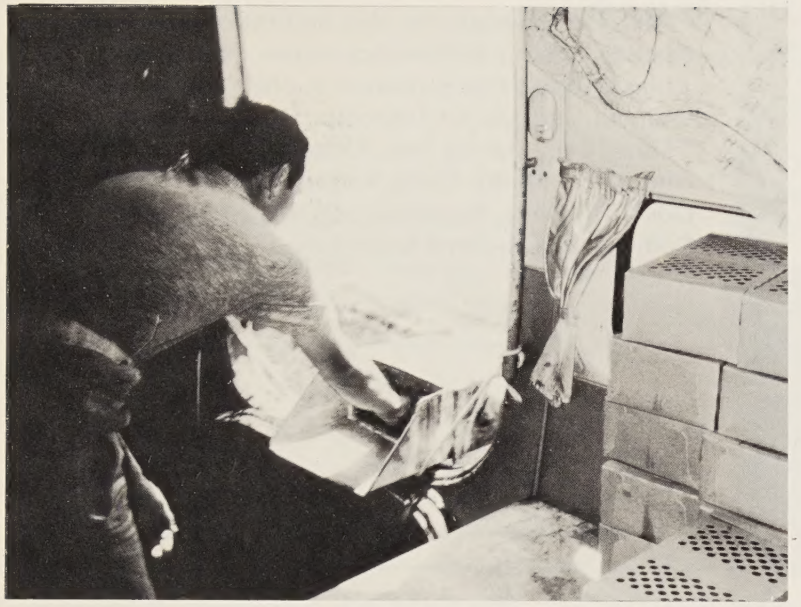
Isao Tomikawa (left) and Entomologist Hitoshi Kamasaki sterilizing fruit flies by irradiating them in the pupal stage.

Male annihilation is another area control and eradication technique, and is especiallly suitable when a powerful male lure has already been discovered, as methyl eugenol for the oriental fruit fly. This method utilizes the dropping of wafers saturated with a male lure combined with an insecticide that attracts and kills only the male flies. By eliminating the males, the females are not mated and oviposit only infertile eggs which, of course, do not hatch. A heavy infestation of the oriental fruit fly was eradicated also from Rota by this method. The males responded to the poisoned lure before any attained sexual maturity, the females' eggs thus failed to hatch, and the species disappeared. Later the same method was used to eradicate the oriental fruit fly from Saipan and Tinian. Thus the oriental fruit fly is now absent from the Mariana Islands from whence it probably came to Hawaii in 1946.

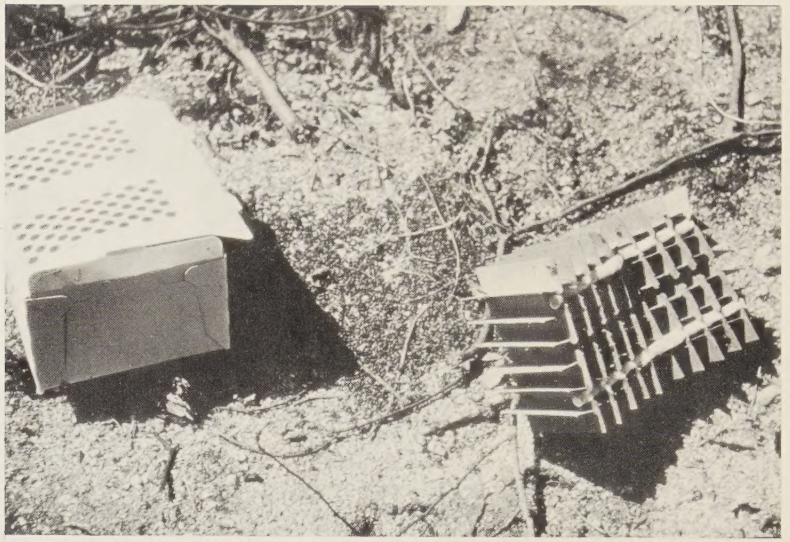


Martin Fujimoto (left) and Entomologist Hitoshi Kamasaki packing sterilized pupae for air shipment to Guam and other islands.

Repackaging pupae on Guam into smaller cartons for release of adult sterilized fruit flies by airplane.



Dropping packaged adult flies by airplane.



Break-apart carton on ground after dropping from airplane, scattering sterilized fruit flies.

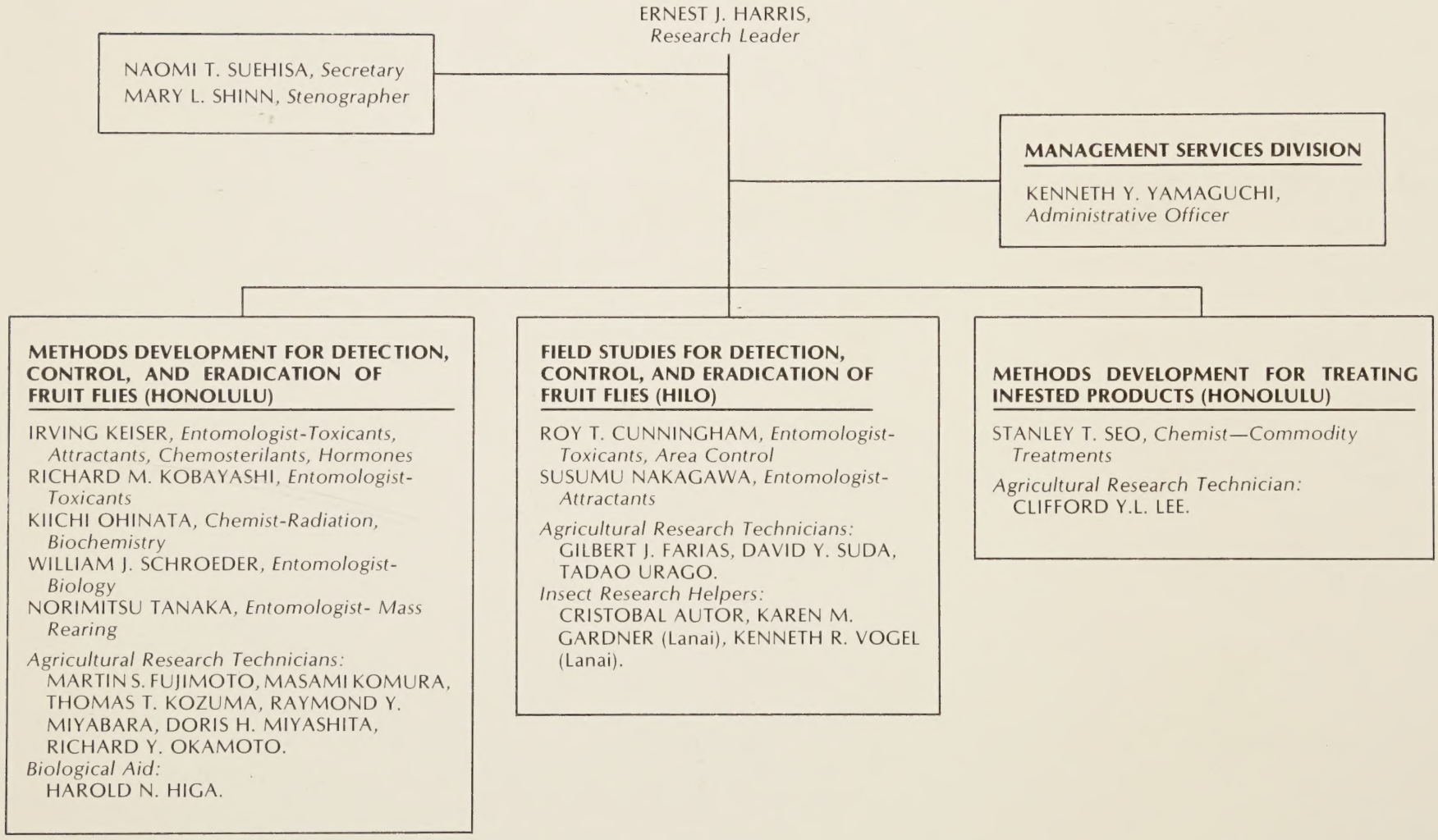
Karen Gardner and Kenneth Vogel preparing test cages on Lanai for evaluating fruit fly area control and eradication operations on that island.

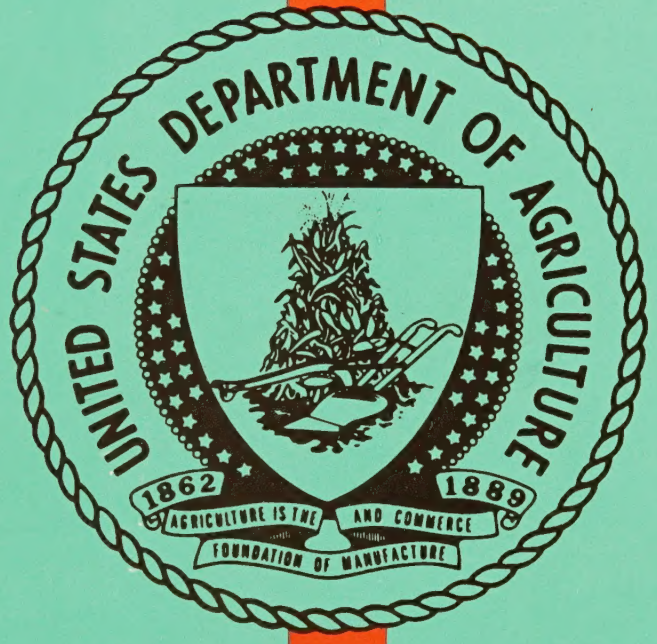
We posed especially for this dedication brochure. **Seated: (l. to r.)** William Schroeder, Norimitsu Tanaka, Ernest Harris, Naomi Suehisa, Kiichi Ohinata, and Martin Fujimoto. **Standing: (l. to r.)** Clifford Lee, Stanley Seo, Richard Okamoto, Harold Higa, Mary Shinn, Irving Keiser, Thomas Kozuma, Doris Miyashita, Raymond Miyabara, Masami Komura, and Richard Kobayashi.

Our Hilo personnel are **(l. to r.)** Gilbert Farias, Tadao Urago, Roy Cunningham, Cristobal Autor, David Suda, and Susumu Nakagawa.

HAWAIIAN FRUIT FLIES LABORATORY

(Personnel on October 10, 1973)




UNITED STATES DEPARTMENT OF AGRICULTURE
1862
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AGRICULTURE IS THE FOUNDATION OF MANUFACTURE
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